Band structure determination for finite-size 3-D photonic crystals

Muriel Botey[(1)], Marc Maymó[(2)], Jordi Martorell[(2)]
[(1)]Departament de Física i Enginyeria Nuclear, Universitat Politècnica de Catalunya
Comte d'Urgell 187, 08036 Barcelona,
[(2)]ICFO, Institut de Ciències Fotòniques, Jordi Girona 29, Nexus II, 08034 Barcelona,
Catalonia, Spain

Since the early days of the photonic crystal field, disagreements between experimental results and some of the predictions based on plane-wave expansions with periodic boundary conditions have been reported [1]. In the present work, we have developed a model based on light diffraction, the Green-function formalism, and the transfer matrix method, and used it to determine the partial band structure of a face centered cubic colloidal crystal. We have applied this model to determine the band along the LU direction of such crystal. As shown in the figure a very good agreement between the numerical calculation of the bandwidth and the experimental measurement of the same bandwidth is found. These results are then compared with the band structure predicted by the usual plane wave expansion method. The discrepancies between this last model and the experimental measurements can be clearly attributed to the finite character of an actual crystal with respect to the infinite character of the modal methods. To conclude, the fact that no periodic boundary conditions in the direction perpendicular to the set of planes are applied in the model presented, suggests that if such finite character were to be applied to other models one might be able to close the gap between the experimental observations and the predictions of previous band structure calculations.

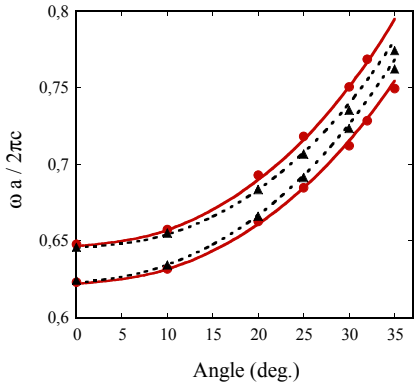

Figure. Comparison of the experimental and predicted photonic band in the LU direction of a photonic crystal made 920 (111) layers of polystyrene spheres, of 147nm in diameter, suspended in water. Dots (triangles) correspond to the s-polarized (p-polarized) measurement, while the solid (dotted) curve stands for prediction in the s (p) polarization.

[1] I. Ínaç Tarhan and George H. Watson, Phys. Rev. Lett. **76**, 315 (1995).